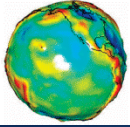


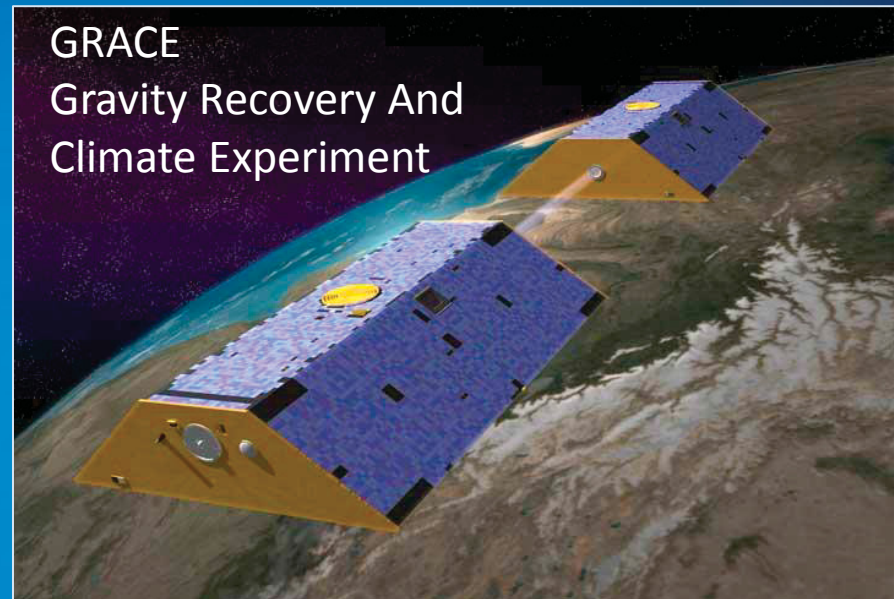
A record-high Ocean Bottom Pressure in the South Pacific observed by GRACE

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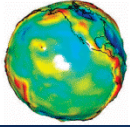
Satellite Data



$$h_{\text{total}} = h_{\text{steric}} + h_{\text{mass}}$$

wind forcing: τ





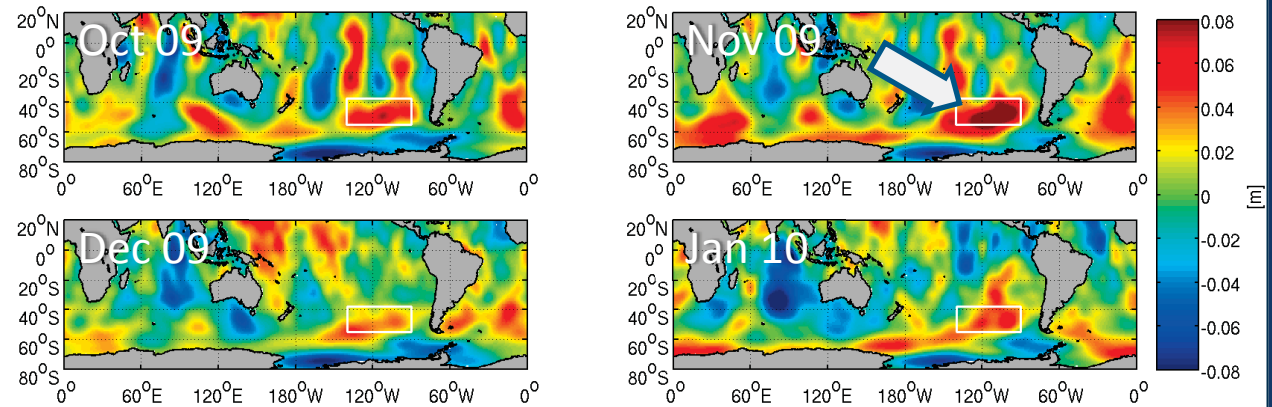
Record Anomaly

GRACE observed record-high ocean bottom pressure anomaly in Nov. 2009 in the South Pacific

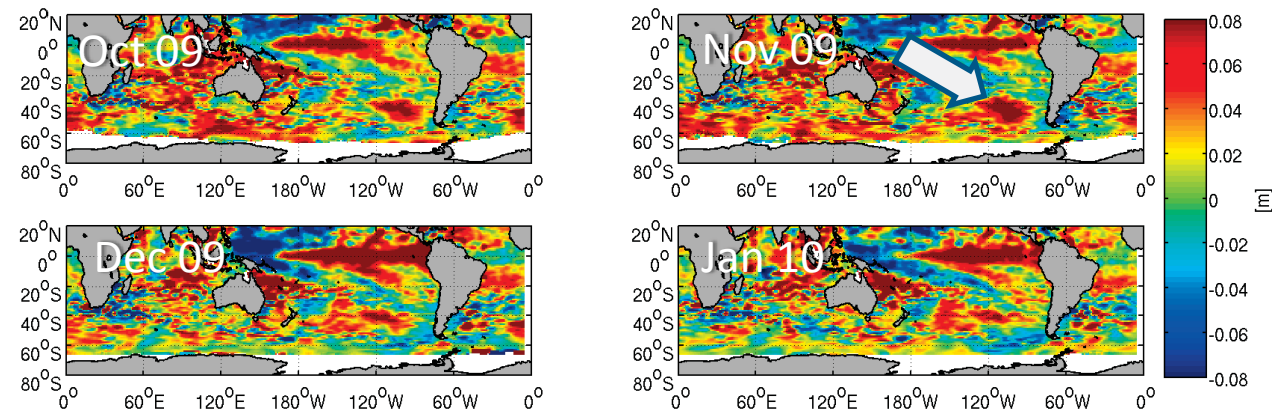
Scientific questions:

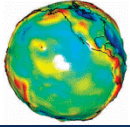
- What is the nature of the OBP/SSH changes?
- What caused the record-high anomaly?

Ocean Bottom Pressure (OBP)

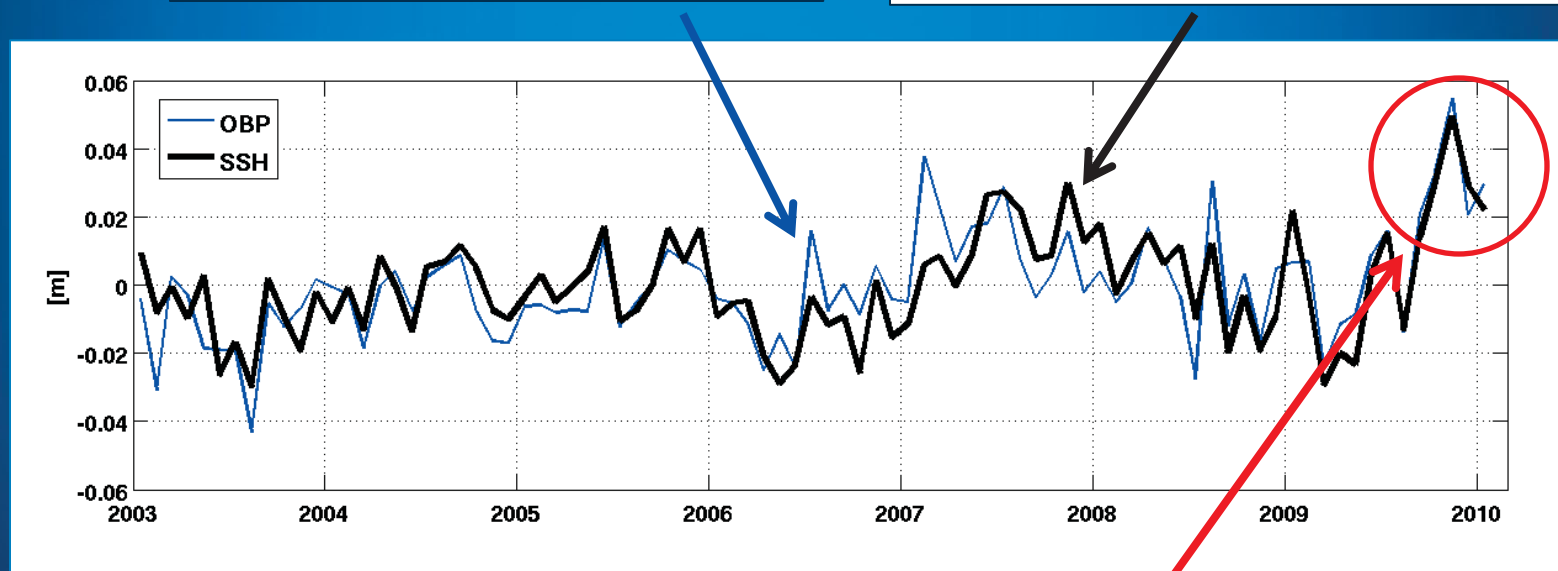
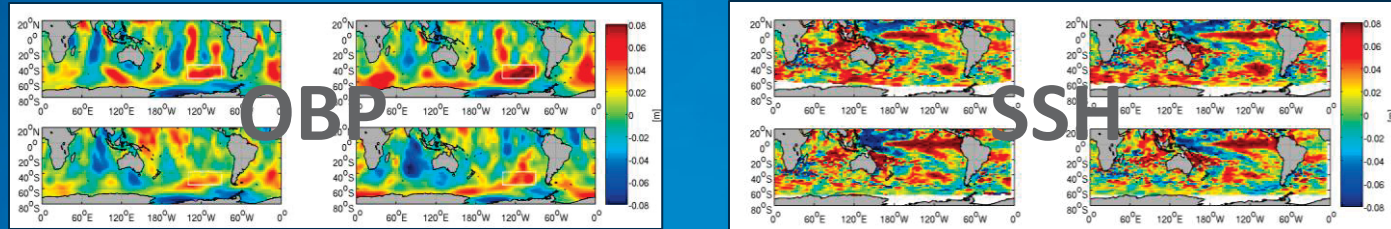


Sea Surface Height (SSH)

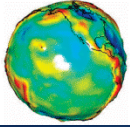




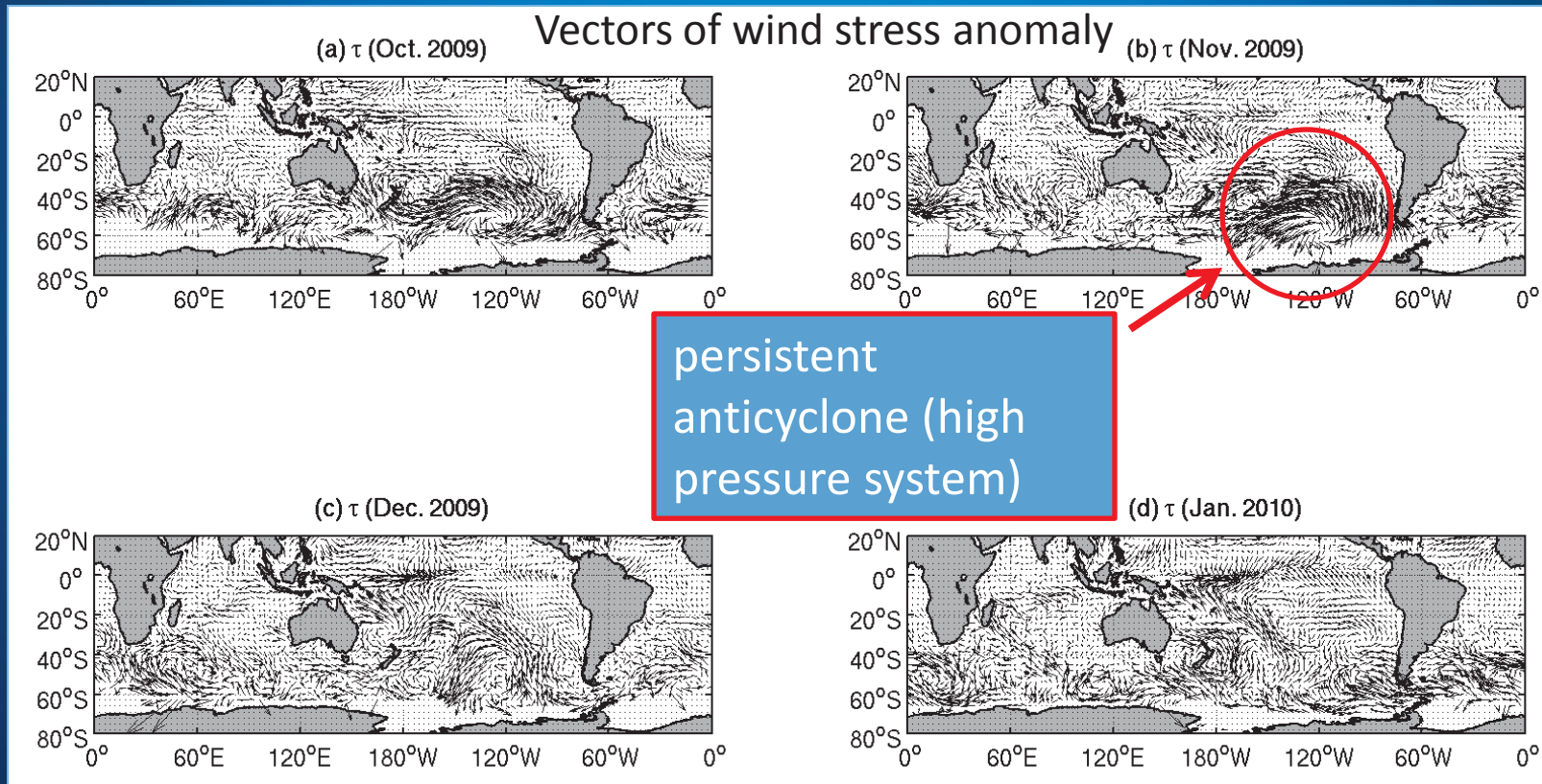
Changes due to mass vs. density

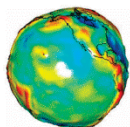


Agreement indicates barotropic (depth-independent) mass convergence is the primary cause for the SSH increase.



Role of Forcing (ASCAT)





Oceanic response to wind forcing

Relation among SSH (η) & atm. wind (τ) & pressure (P_a) & friction (r) & topography (H)

$$\underbrace{\frac{\partial}{\partial t} \left(\frac{\partial \eta}{\partial x} - \frac{\partial \eta}{\partial y} \right)}_{\text{relative vorticity \& vortex stretching}} + \underbrace{\beta \frac{\partial \eta}{\partial x}}_{\text{planetary effect}} - \underbrace{\frac{f}{H} \left(\frac{\partial \eta}{\partial x} \frac{\partial H}{\partial y} - \frac{\partial \eta}{\partial y} \frac{\partial H}{\partial x} \right)}_{\text{topography effect}} + \underbrace{\nabla \cdot \left(\frac{r g}{f H} \nabla \eta \right)}_{\text{damping}} = \underbrace{\frac{f}{\rho g} \nabla \times \frac{\tau}{H} - \frac{1}{g H \rho} \frac{\partial^2 P_a}{\partial x^2}}_{\text{wind \& pres. forcing}}$$

relative vorticity
& vortex
stretching

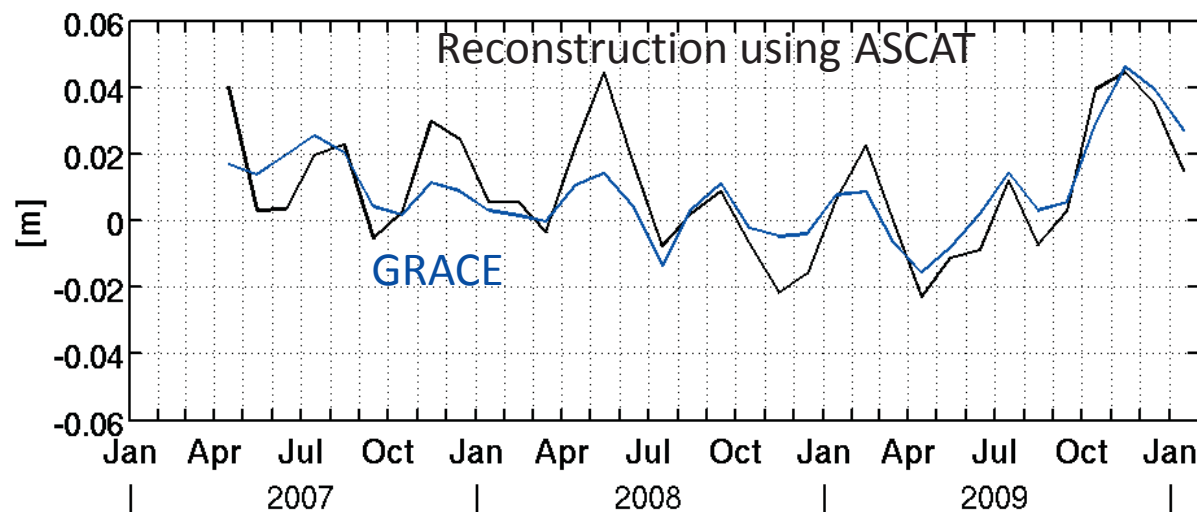
planetary
effect

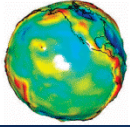
topography effect

damping

wind & pres. forcing

Reconstruction of
sea level anomalies
using ASCAT data
agrees well with
GRACE
observations.

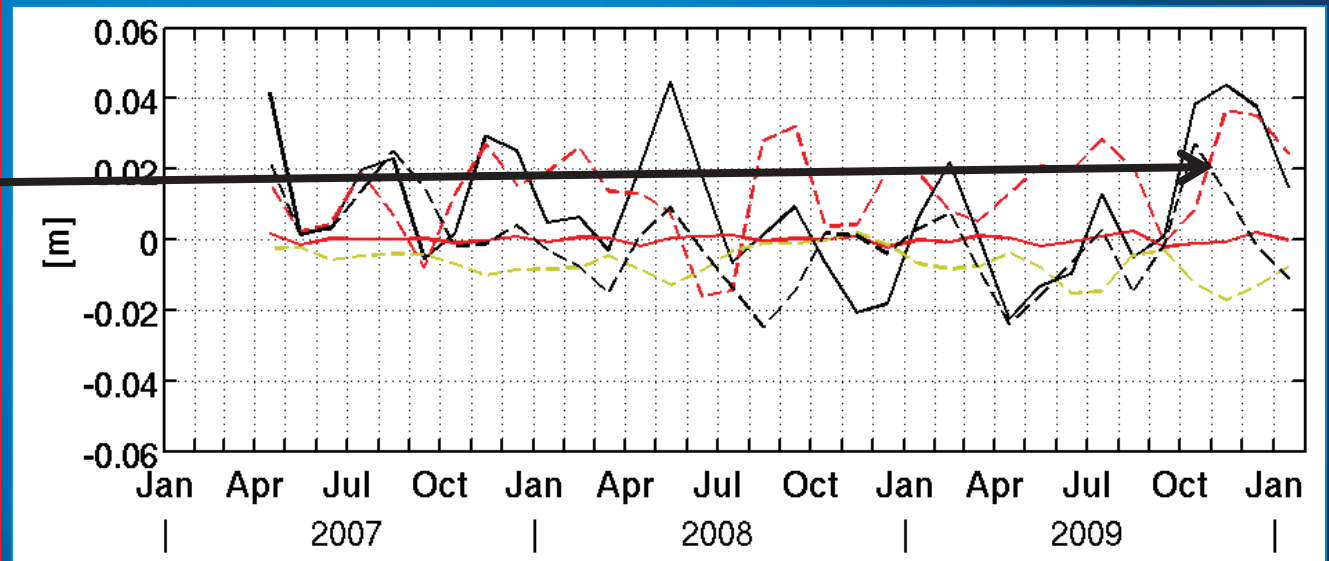


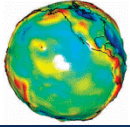


Dominant dynamical balance

$$\beta \frac{\partial \eta}{\partial x} - \frac{f}{H} \left(\frac{\partial \eta}{\partial x} \frac{\partial H}{\partial y} - \frac{\partial \eta}{\partial y} \frac{\partial H}{\partial x} \right) + \nabla \cdot \left(\frac{r g}{f H} \nabla \eta \right) = \frac{f}{\rho g} \nabla \times \frac{\tau}{H}$$

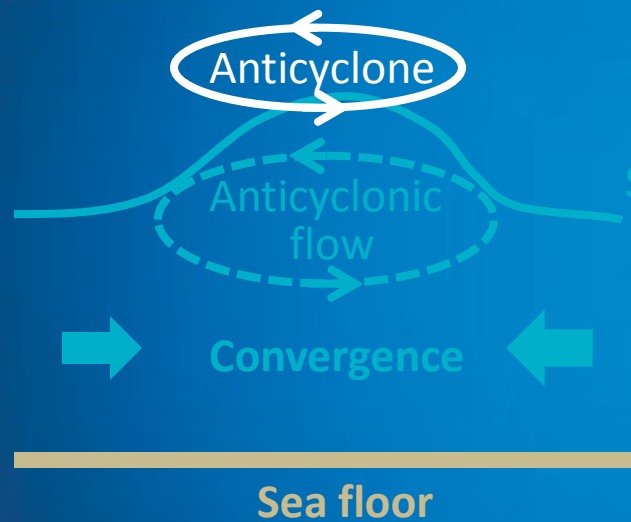
- Overall: bottom topography important
- Late '09 record anomaly: balance between β -term and wind forcing + topography effect modified by friction.



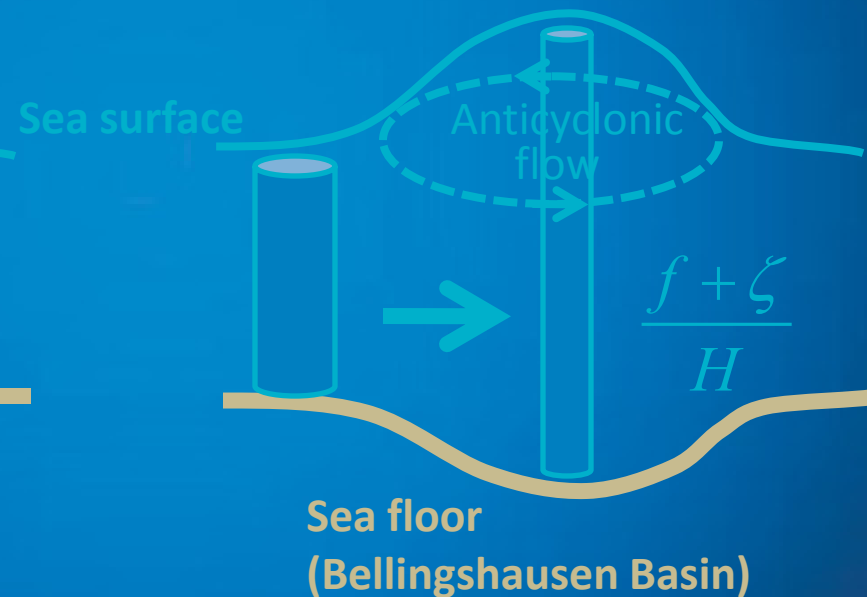


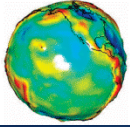
Schematics of

Wind forcing



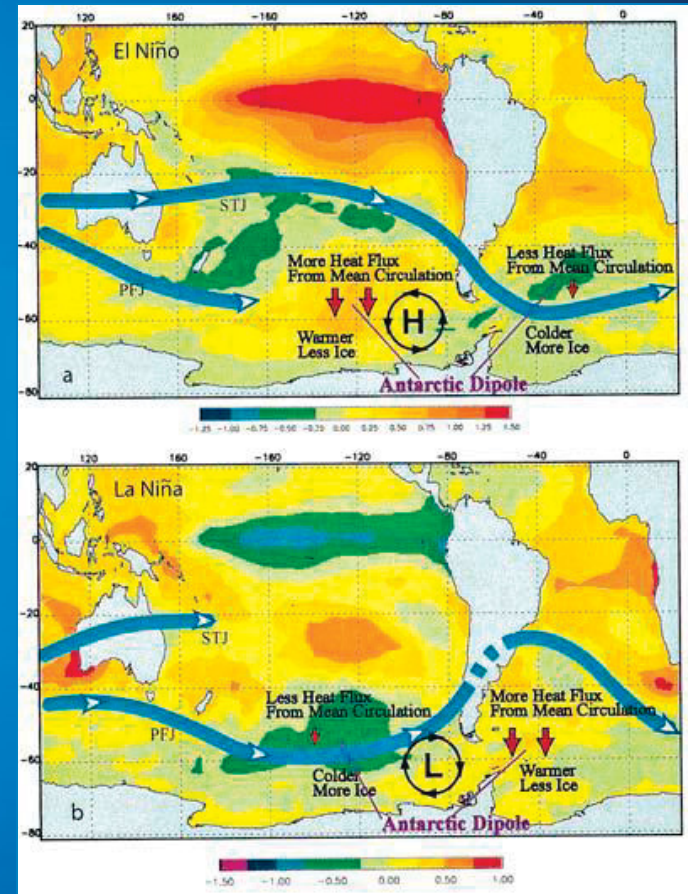
Topographic effect



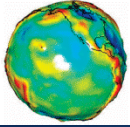


Teleconnection and Impact

- Possible role of the 2009-10 El Niño in causing the extreme & persistent SP anticyclone (atmospheric linkage)
- Potential impact on Southern Ocean and Antarctica due to diversion of circumpolar westerly wind and the Antarctic Circumpolar Current (oceanic connection).



Picture from Yuan (2004)



Conclusions

- A demonstration of GRACE's capability in capturing oceanic features.
- GRACE recorded an extreme OBP anomaly in the S. Pacific in 2009.
- GRACE helps understand a similar signal in altimeter SSH data: the SSH signal is due to mass change.
- The OBP signal is associated with a strong & persistent anticyclone.
- The re-enforcement of the topographic effect by the wind stress curl associated with the strong anticyclone is the main reason for the record increase of OBP in late 2009.
- Possible connection to 2009/10 El Nino and impacts on the Antarctic Circumpolar Current.

Thank you!